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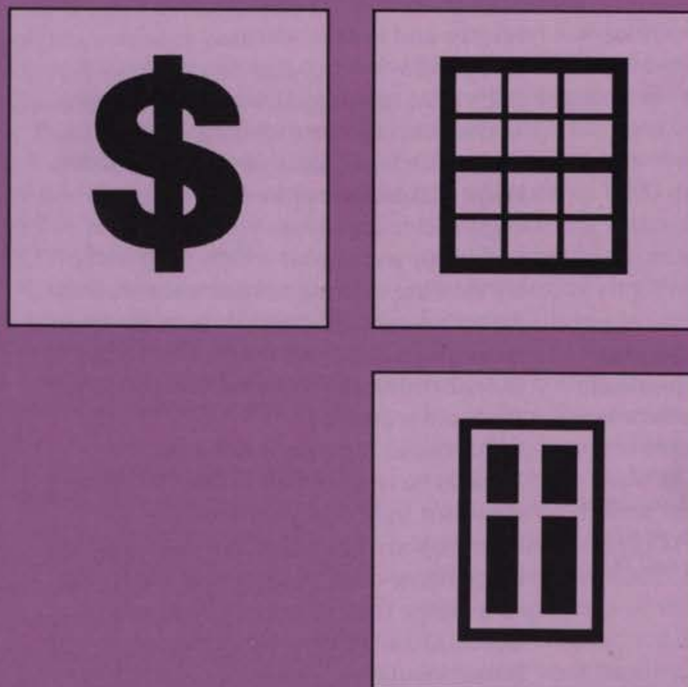
Savings By Insulation



Council Notes

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College of Fine and Applied Arts – University of Illinois

This publication will help you estimate the energy that can be saved by insulating ceilings, walls, foundations, doors, and windows.

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Just like human beings, houses are warm-blooded. People and houses both need fuel and an internal source of heat to maintain a steady temperature. We are healthiest when our inside body temperature is about 98.6°F. We keep our houses at about 70°F to help us maintain that internal temperature. When the weather turns colder, both houses and people lose more heat to the outside than when its warmer. We have to make an effort, and burn more fuel, to keep the inside of our houses and bodies warm.

A good winter coat slows the loss of body heat making it easier for the body to maintain its internal temperature. In other words, a coat is ***insulation*** for the body. Insulation applied to walls, ceilings, and foundations wraps a house, just like a warm coat wraps your body. By slowing the rate of heat transfer, insulation saves fuel, which in turn, saves money. An insulated house also feels more comfortable because the inside surfaces are warmer.

Of course, a house is not a person. Houses have doors for access and windows for light and ventilation. These openings are like holes in a coat. Because more home owners than ever are trying to manage their energy dollars wisely, doors and windows are being made with better insulating values and energy saving improvements.

This publication provides information for estimating the energy that can be saved by insulating various house components: walls, ceilings, foundations, windows, and doors. By knowing the energy savings, one can determine the dollar savings and the return on an investment in energy conservation.

WORKSHEET METHOD

A building's size, its heating system, and the amount and type of insulation it has affects how much energy it will take to heat it. Because energy use is different for each building, energy savings for a particular building can't be looked up in a book. Energy savings can, however, be estimated. The enclosed worksheet, together with the energy use tables, will allow you to make the calculations to estimate energy savings through insulation. Whether you are calculating the savings for insulating walls and ceilings, or for installing storm windows, the worksheet steps are the same. Feel free to copy the worksheet as many times as you like.

The energy use tables show the heat lost through ceilings, walls, foundations, doors, and windows. Energy use is expressed in terms of the natural gas that is used to offset the heat loss through a wall, door, window, etc. The numbers from the tables are used in the worksheets to calculate energy and cost savings.

Therm

A therm is a unit of energy, and is typically the unit by which natural gas is sold. One therm equals 100,000 Btus.

R-Value and U-Value

The R-value is a measure of resistance to heat flow: the higher the R-value the better the insulating properties of the material or component. Insulations are rated by their R-value.

U-value is the inverse of R-value. U-value is the measure of how much heat a material conducts; the lower the U-value the better the insulating properties of the material. Windows are commonly rated by their U-value.

Degree Days

The term *degree days* refers to the severity of a region's winter. The higher the degree days, the more severe the winter. In the United States, degree-day values range from below 1000 in southern Florida, to close to 10,000 on the Canadian border. For each day of the heating season, the mean daily temperature is subtracted from 65 degrees, which is the number of degree days for that particular day. The daily values over the entire heating season are added together to get the seasonal total. The degree-day map in this publication shows these seasonal degree-day totals. Clearly, the severity of a region's winter is vital to determining the savings one realizes from improving insulation.

These are the basic steps you need to fill out a worksheet:

- ▲ STEP 1. Find the size, or area, of your wall, ceiling, door, or window to be insulated. The tables are all based on a certain size. How does your size compare? The result of this step is used in steps 2 and 3.
- ▲ STEP 2. Find out how much heat you are presently losing through this area each year. This number comes from the table. It will be the amount of natural gas used to make up for the heat lost through this area each year.
- ▲ STEP 3. Find out how much heat you would lose after you improve on the insulation. This number also comes from the table. It will be the expected amount of natural gas needed to make up for the heat lost through this area each year after the improvement is made.
- ▲ STEP 4. Find out how much energy you could save by insulating. Subtract the answer in step 3 from the answer in step 2. The result is the amount of natural gas you would save every year by insulating.
- ▲ STEP 5. If your house uses a different fuel, find out the energy savings in terms of the fuel you use. The result is the amount of gallons of fuel oil, gallons of LP gas, or kilowatt hours of electricity you would save every year.
- ▲ STEP 6. Determine your yearly dollar savings. Knowing what you pay for your fuel (just look at your last bill), you can find out how much money the improvement in insulation will save you in heating costs each year.
- ▲ STEP 7. Finally, you can find out what the return on your investment will be for adding the extra insulation. Knowing what it will cost to make the improvement, you can determine what percentage of that cost you will get back each year by lowering your heating bills.

An example is presented with each table showing the savings calculated on a sample worksheet. Take a close look at the examples before you begin your own work.

The worksheet is written assuming that insulation is being added to an existing home, but the calculations work just as well for new construction or an addition. In those cases you can compare what you might save if you use one insulation instead of another. Think in terms of "Option 1" and "Option 2" where the worksheet says "existing" and "after improvement."

The figures in the tables are estimates because weather conditions, quality of building construction, site conditions, and living habits are not the same for each house and every family.

USE OF TABLES

The heat loss tables consist of rows and columns. To use the tables, first determine the **degree days** (a measure of winter severity) for your locality. Page 5 of this publication shows a degree-day map (in intervals of 1,000 degree days) for the 48 neighboring states and southern Canada. Locate your community and the nearest degree-day lines. For example, Chicago, Illinois is near the 6,000 degree-day line. The degree-day values correspond to column headings in each table. If you live about midway between two lines, it is possible to average the table values for the two degree-day columns. For instance, Champaign, Illinois is between 5,000 and 6,000 degree days. Any greater degree of accuracy from the tables, (to quarters or thirds), is not practical. After finding out the degree-day value for your locality, use this column for all subsequent calculations. Ignore the other columns.

The rows correspond to **R-values** or type of building component. Use the suitable row to determine the heat loss for that building part or level of insulation.

The center of each table lists numbers showing heat loss in **therms** for a certain area. When you know the degree days for your area and the insulation level you are calculating for, you can find this number in the table. It will be used in the worksheet.

CEILING INSULATION

A lot of heat may be lost through the ceilings of a house's top floor. There is often plenty of room for more insulation in the attic area above these ceilings. For this reason attics are often the focus of energy saving improvements.

R-values for ceiling insulation materials range from about 2.0 to 4.0 per inch, depending on the material, its density, average outdoor temperature, and the quality of installation. Settling or shrinking may reduce how well insulation works over time. Most insulation materials have the R-value printed on the packaging. If you are in doubt, ask your supplier for the R-value of your insulation material.

If there is insulation in your attic now, you may use the following figures to estimate its R-value:

- vermiculite–R-2 per inch of thickness;
- mineral wool, glass fiber, cellulose–R-3 per inch of thickness.

The values in **Table 1** on page 6 for therms per season include an allowance for the R-value of the ceiling construction. The illustration with the table shows a flat ceiling attic. This table will work just as well for cathedral ceilngs, provided the ceiling area is calculated carefully.

Savings for Other Fuels

Use the tables in this publication to determine savings in therms of natural gas.

Oil. Multiply the savings in therms by **0.7** to get savings in terms of gallons of fuel oil per season. These estimates are based on a well-maintained and properly operating oil burner both **before** and **after** the change in insulation.

LP Gas. Multiply the savings in therms by **1.08** to determine the savings in gallons of LP gas.

Electrical Resistance Heating. Multiply savings by **20.5** to get savings in kilowatt-hours of electricity. This is based upon resistance heating, either baseboard or ceiling cable located in the room. For an electric furnace, multiply by **21.5**.

Electric Air-to-Air Heat Pump. If operating data for seasonal operation is available locally, your power supplier may help you determine the multiplier for your locality. If such data are not available, use the multiplier given below.

Zones	Multiplier
2,000-3,000	**12**
4,000-5,000	**15**
6,000-7,000	**17**
8,000-10,000	**18**

WALL INSULATION

Outside walls are often the largest surface area for heat loss. Many older homes were constructed without any insulation in the walls. If your walls are not insulated, they probably should be.

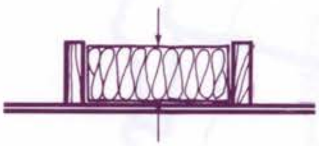
In figuring the savings for insulating walls, consider only the **net wall area**, which you can find by subtracting the total area of windows and exposed doors from the overall wall area. Remember to consider only the net wall areas that are to be improved by insulation.

Table 2 on page 7 shows a range of typical R-values for outside walls. The R-value for the wall construction itself has been included in the table. The R-6 insulation shown is no longer available, but it may be found already installed in some houses. The 8-1/2-inch and 10-1/2-inch stud spaces are for double-wall construction, which is a very energy efficient design.

Heating Degree-Days
65°F Base
Redrawn from The National Atlas of the United States of America, 1970

Table 1. Ceiling Insulation

(therms of natural gas burned per season to replace heat lost through 1,000 sq. ft. of ceiling)



R-Value of Insulation in Ceiling	Degree-day Zone 2000	3000	4000	5000	6000	7000	8000	9000	10000
0	192	297	408	519	631	740	850	964	1076
1	144	223	306	389	474	555	637	723	807
3	96	148	204	260	316	370	425	482	538
5	72	111	153	195	237	278	319	362	404
7	52	83	115	147	179	212	245	278	311
9	43	69	96	123	149	177	204	231	260
11	37	59	82	105	128	151	175	198	222
13	33	52	72	92	112	133	153	174	195
15	29	46	64	82	100	118	136	154	173
17	23	38	54	69	85	102	118	134	151
19	21	35	49	63	78	92	107	122	137
21	19	32	45	58	71	85	98	111	126
24	17	28	40	51	63	75	87	99	112
30	14	23	33	42	52	62	71	81	91
38	9	16	23	30	38	45	52	60	68
44	8	14	20	26	33	39	45	52	59
50	7	12	18	23	29	35	40	46	52
56	6	11	16	21	26	31	36	42	47

EXAMPLE 1 - CEILINGS

A house in Chicago (6000 degree days) has an attic floor space of 30′ x 40′. This 1200 sq. ft. ceiling presently has only three inches of mineral wool insulation. This is equal to about R-9 insulation. The house is heated with fuel oil, which costs $1.15/gallon. The owner is considering installing 10″ fiberglass batts, having an R-value of R-30, over the existing insulation, which would cost $600. What are the expected savings for this installation?

1. **Area.** The area is 1200 sq. ft., and the standard area in the table is 1000 sq. ft., so the area adjustment is 1.2. This adjustment carries down to lines 2 and 3.

2. **Existing Energy Loss**. The existing energy loss, from the table (Degree-day column "6000", R-Value row "9"), is 149 therms/year times 1.2, or 178.8 therms/year.

3. **Expected Energy Loss.** After the improvement, the expected energy loss (Degree-day column "6000", R-Value row "38") is 38 therms/year times 1.2, or 45.6 therms/year.

4. **Energy Savings.** The additional insulation would save 149 - 45.6 = 133.2 therms/year.

5. **Fuel Conversion.** Since the house is heated with fuel oil instead of natural gas, the energy savings is converted to gallons of fuel oil, 133.2 x 0.7 = 93.24 gallons/year.

6. **$ Savings.** At $1.15/gallon, the improvement would save $1.15 x 93.24 = $107.23/year.

7. **Return on Investment.** Dividing the savings by the cost of the improvement, one would expect a 18% annual return on investment.

Energy Cost Savings Worksheet

Degree Days = 6000 Insulation For = Ceiling

1. My surface area 1200 divided by Standard surface area (from chart) 1000 = 1.2 Surface area adjustment

2. Existing energy loss (from chart) 149 x 1.2 = 178.8 Therms/yr loss

– (subtract)

3. Expected energy loss after improvement (from chart) 38 x 1.2 = 45.6 Therms/yr loss

4. Energy savings 133.2 Therms/yr saved

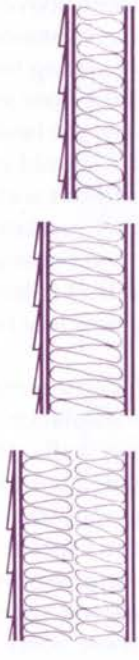
5. Fuel Conversion 0.7 x 133.2 = 93.24 Gallons/kWh/yr saved

6. $ Savings Fuel cost per therm/gallon/kWh $ 1.15 x 93.24 = $107.23

7. Annual return on investment: $ Savings $107.23 / Cost of improvements $600.00 x 100 = 18 %

Table 2. Wall Insulation

(therms of natural gas burned per season to replace heat lost through 1,000 sq. ft. of wall)



Wall stud size	R-value of insulation in stud space	Degree-day zone 2000	3000	4000	5000	6000	7000	8000	9000	10000
2 x 4	none	144	223	306	389	474	555	637	723	807
	R-6	58	89	122	156	189	222	255	289	323
	R-11	37	59	82	105	128	151	175	198	222
	R-13	33	52	72	92	112	133	153	174	195
2 x 6	R-19	21	35	49	63	78	92	107	122	137
Double stud 8-1/2″ space	R-30	11	19	28	37	46	56	65	74	84
Double stud 10-1/2″ space	R-38	9	16	23	30	38	45	52	60	68

EXAMPLE 2 - WALLS

A one story house in Springfield (5000 degree days) has no insulation in the walls. The house measures 30′ x 50′, with 8′ tall, 2x4 walls. The total door and window area is 220 sq. ft. The total exterior wall surface area is then: 240 + 240 + 400 + 400 - 220 = 1060 sq. ft. The house is heated with electric baseboard heat costing $.04/kWh. An estimate for blowing in cellulose insulation (R-11) in the exterior walls comes to $1900. What is the expected energy and cost savings for the owner after the improvement?

1. **Area**. The area is 1060 sq. ft., and the standard area in the table is 1000 sq. ft., so the area adjustment is 1.06. This adjustment carries down to lines 2 and 3.

2. **Existing Energy Loss**. The existing energy loss from the table ("5000" degree-day column, "none" R-Value row) is 389 therms/year times 1.06 or 412.3 therms/year.

3. **Expected Energy Loss**. After blowing in insulation, the expected energy loss ("5000" degree-day column, "R-11" row) is 105 therms/year times 1.06 or 111.3 therms/year.

4. **Energy Savings**. The additional insulation would save 412.3 - 111.3 = 301 therms/year.

5. **Fuel Conversion**. Since the house is heated with electric baseboard heat instead of natural gas, the energy savings is converted to kWh, 301 x 20.5 = 6170.5 kWh/year.

6. **$ Savings**. At $.04/kWh, the improvement would save 6170.5 x .04 = $246.82/year.

7. **Return on Investment**. Dividing the savings by the cost of improvement, one would expect a 13% annual return on investment.

Energy Cost Savings Worksheet

Degree Days = 5000 Insulation For = Walls

1. My surface area 1060 divided by Standard surface area (from chart) 1000 = 1.06 Surface area adjustment

2. Existing energy loss (from chart) 389 x 1.06 = 412.3 Therms/yr loss

– (subtract)

3. Expected energy loss after improvement (from chart) 105 x 1.06 = 111.3 Therms/yr loss

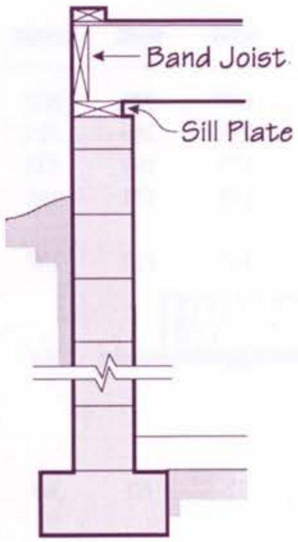
4. Energy savings 301 Therms/yr saved

5. Fuel Conversion 20.5 x 301 = 6170.5 Gallons/kWh/yr saved

6. $ Savings Fuel cost per therm/gallon/kWh $ .04 x 6170.5 = $246.82

7. Annual return on investment = $ Savings $246.82 / Cost of improvements $1900 x 100 = 13 %

FOUNDATIONS



Basements

Many heating contractors overlook heat loss from basements. They think the space will be kept warm by heat lost from the furnace or boiler casing and from ducts and pipes that pass through the basement. Heat loss from a basement is as costly as heat loss from a living room. Reducing basement heat loss will result in a warmer basement and warmer floors above it.

Insulating foundations can be done on either the outside or inside of the foundation. If the house is already built, however, it is much easier to insulate the walls on the inside. One way to do this is to build a wall just inside the foundation with 2 x 4s, and insulate this new wall with fiberglass batt insulation. This works well, but will take about 5" of floor space all around the basement. Another method is to put rigid foam insulation on the walls, which can save floor space in the basement. Building codes require that rigid foam insulation be covered with a fire resistant material such as drywall.

A lot of heat can be lost through the band joist if it is not insulated. This is the space above the masonry foundation where the floor joists sit on the sill plate, which lies flat on top of the foundation wall. (See the drawing on this page.) Air can leak into the house underneath the sill plate too, so caulk this crack before you add insulation to the band joist. Weather-strip and add storm windows to the inside or the outside of basement windows.

Table 3 on page 9 for basement insulation assumes that there is no leakage at the band joist and around the windows. This table provides the energy use after insulating the band joist area, and insulating the basement wall with either R-4 foam insulation, or R-11 batt insulation.

Crawl Spaces

Crawl spaces should be dry and well above the water table. The ground surface should be covered with a layer of thick plastic to prevent water vapor from the ground from traveling into the crawl space and then into the house above it.

If your house has electric resistance heating, you may place insulating batts (as high as R-19) between the floor joists over the crawl space to slow the heat loss from the rooms above. This should only be done in crawl spaces without water pipes or heating ducts. After insulating the floor, the crawl space will become much colder, which could lead to frozen water pipes and wasteful heat loss from the heating ducts.

Another good way to insulate a crawl space is to put rigid foam insulation on the inside of the foundation walls. The band joist should be insulated with R-19 batts. The crack under the sill plate should be sealed. Most crawl spaces have vents in the wall to help remove excess moisture. If there is a good vapor barrier over the ground, these vents should be closed and sealed in the winter.

Table 3 shows the energy use after insulating the band joist, and insulating the walls with R-4 insulation. The table assumes that there is no air leakage around the sill plate and vents, and does not include heat gain from water pipes and heating ducts.

Table 3. Foundation Insulation

(therms of natural gas burned per season to replace heat lost through 10 feet of foundation perimeter)

Foundation type	Degree-day zone 2000	3000	4000	5000	6000	7000	8000	9000	10000
Basement									
Uninsulated	4	7	11	15	19	23	29	35	40
Add R-19 to band joist only	3	6	8	12	15	19	24	29	34
Plus R-4 to foundation wall	2	3	4	6	8	10	13	15	18
Plus R-13 to foundation wall	1	2	2	4	5	6	7	9	10
Crawl Space									
Uninsulated	4	6	8	11	13	15	18	20	23
Band joist insulated only	3	5	7	10	12	14	16	18	20
Band joist insulated, R-5 on foundation walls	2	3	4	6	7	8	10	11	12

EXAMPLE 3 - FOUNDATIONS

A house in a cold climate (8000 degree days) is built over an uninsulated crawl space. The perimeter of the crawl space is 160 feet. The house is heated with natural gas at $.45/therm. The owner plans on insulating the crawl space with R-19 fiberglass in the band joist, and putting R-5 foam insulation on the foundation walls. The owner can do this work himself, but the materials will cost $380. What is the expected annual energy and cost savings?

1. **Area**. In foundation calculations, perimeter of foundation is used instead of area. The perimeter is 160 feet and the standard perimeter in the table is 10 feet, so the area adjustment is 16. This adjustment carries down to lines 2 and 3.

2. **Existing Energy Loss**. The existing energy loss from the table (Degree-day column "8000", R-Value row "uninsulated") is 18 therms/year times 16 , or 288 therms/year.

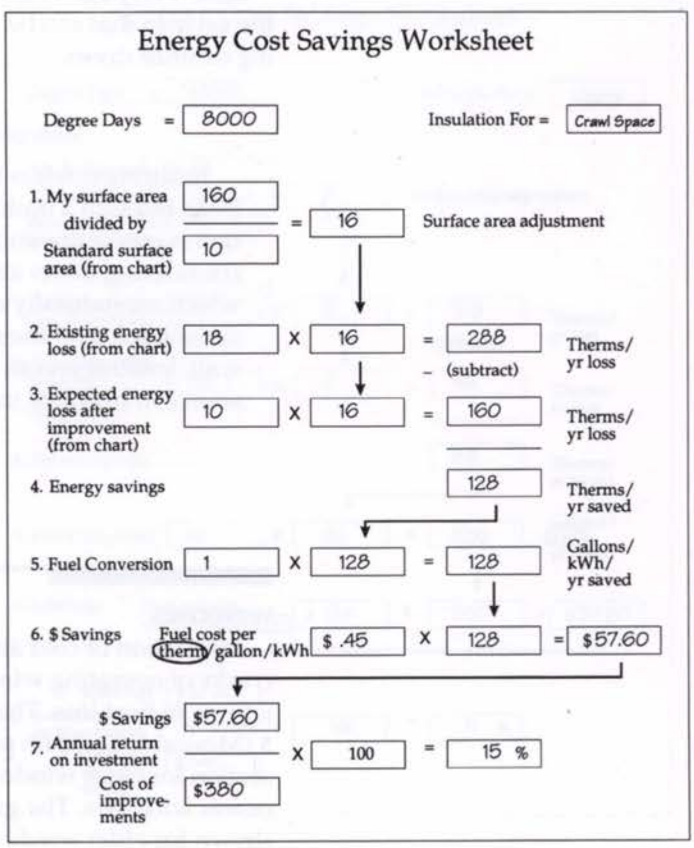
3. **Expected Energy Loss**. After the improvement, the expected energy loss (Degree-day column "8000", R-value row "insulated") is 10 therms/year times 16, or 160 therms/year.

4. **Energy Savings**. The improvement would save 288 - 160 = 128/year.

5. **Fuel Conversion**. Since the house is heated with natural gas, no conversion is necessary.

6. **$ Savings**. At $.45/therm, the improvement would save $.45 x 128 = $57.60/year.

7. **Return on Investment**. Dividing the savings by the cost of the improvement, one would expect a 15% annual return on investment.



DOORS

Outside doors can contribute substantially to the heat loss of a house. The **infiltration** of cold air around a door can be just as important as the R-value of the door in reducing heat loss. For this reason, weatherstripping outside doors should be the first step in improving outside doors. A seperate storm door is also a good idea. An insulated metal door is almost as effective as a tight-fitting wood door plus a storm door.

Sliding glass doors are also large energy users. Because sliding doors are permanently fit in tracks, leakage of cold air to the inside is usually less than from swinging doors. The large expanse of glass in sliding glass doors, however, has a low R-value. Doors with factory-sealed double and triple glazing should be used in all but the mildest climates. The south side of a house receives the most gain from solar energy and is usually the best area to have a glass door.

Table 4 on page 11 gives estimates of the savings that can be made by improving exterior doors.

> Infiltration
>
> Infiltration refers to air which leaks through a building. Infiltration is especially important when considering doors and windows, which are naturally more prone to air leakage than the middle of a wall. Infiltration can be a major source of heat loss in a house.

WINDOWS

Infiltration of cold air around the cracks of operating windows plays a major role in heat loss. The first part of **Table 5** (Moveable Sash) on page 12 has one section for older windows and one for newer windows. The greater heat losses shown for older windows are a result of this infiltration.

There are two steps for improving the energy performance of older windows:

- ▲ 1. Weatherstripping to reduce air infiltration; and
- ▲ 2. Adding storm windows, which reduces infiltration and increases the R-value of the windows.

Table 5 for operating windows is based on double hung windows. Other window designs, such as casement and awning windows, do an even better job of reducing infiltration.

The R-values for windows vary widely. In fact, since a window is made up of both frame and glass, there is no single R-value; it depends on where you measure. For this reason, windows are rated for their overall U-value, which is the thermal conductance of the window unit as a whole, both frame and glass. The lower the overall U-value the better the energy performance of the window. The U-value of a window can be obtained from the manufacturer's catalog.

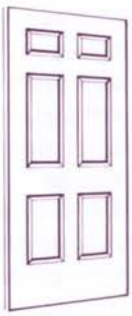
Windows are made with one, two, and three layers of glass, and are called single glazed, double glazed, and triple glazed windows. The more panes of glass, the better the insulating value of the window. Two additional improvements are available with double and triple glazed windows. One improvement is *Low-Emissivity* coatings, which save energy by reflecting heat near a window back into the room. Another is to fill in the space between panes of glass with Argon gas instead of air. Argon slows heat loss more than air does. These two options are often offered together. **Table 5** provides savings estimates for this combination.

Improved glazing makes a room more comfortable by reducing drafts and maintaining warmer glass surfaces. Adding storm windows to prime windows reduces the entry of drafts and noise. Warmer glass surfaces make it possible to have more moisture in the air without having the windows become wet on the inside. The water that you see on your windows in the winter can harm the wood frames of your windows.

Table 5 provides values for figuring savings with operating windows and fixed windows.

Table 4. Doors

(therms of natural gas burned per season to replace heat lost through one 20 sq. ft. door)



	Degree-day zone								
	2000	**3000**	**4000**	**5000**	**6000**	**7000**	**8000**	**9000**	**10000**
Door type									
1 Single door	23	38	54	70	86	102	119	135	152
2 Single door-tight	14	22	32	40	50	59	69	78	88
3 Storm door added	10	16	23	29	36	43	50	56	64
4 Metal door	11	17	25	32	39	47	54	61	69
Sliding door type									
5 Single glazed	30	50	70	90	111	132	153	174	197
6 Double glazed	22	36	51	66	81	97	112	127	143
7 Triple glazed	20	32	45	58	72	85	99	112	127

Notes:
Case (1) Solid wood door 1-3/4" thick, no weatherstripping
Case (2) Same as (1), but with weatherstripping
Case (3) Metal storm door added to case (2)
Case (4) Metal door filled with polystyrene foam, with thermal break
Case (5) to (7) Thermally improved aluminum sliding doors are considered

EXAMPLE 4 - DOORS

A house in southern Illinois (4000 degree days) has two leaky exterior doors without storm doors. The house is heated with a heat pump, and electricity costs .04/kWh. The cost to weatherstrip and install 2 storm doors is $340. What would the annual energy and cost savings be once this work is done?

1. **Area.** The area is 40 sq. ft. and the standard area in the table is 20 sq. ft., so the area adjustment is 2. This adjustment carries down to lines 2 and 3.

2. **Existing Energy Loss.** The existing energy loss from the table (Degree-day column "4000", R-Value row "1") is 54 therms/year times 2, or 108 therms/year.

3. **Expected Energy Loss**. After the improvement, the expected energy loss (Degree-day column "4000", R-value row "3") is 23 therms/year times 2 , or 46 therms/year.

4. **Energy Savings**. The improvement would save 108 - 46 = 62 therms/year.

5. **Fuel Conversion**. Since the house is heated with a heat pump instead of natural gas, the energy savings is converted to kWh, 15 x 62 = 930 kWh/year.

6. **$ Savings**. At $.04/kWh , the improvement would save $37.20/year.

7. **Return on Investment**. Dividing the savings by the cost of the improvement, one would expect an 11% annual return on investment.

Energy Cost Savings Worksheet

Degree Days = 4000   Insulation For = Doors

1. My surface area 40 divided by Standard surface area (from chart) 20 = 2 Surface area adjustment

2. Existing energy loss (from chart) 54 x 2 = 108 Therms/yr loss

– (subtract)

3. Expected energy loss after improvement (from chart) 23 x 2 = 46 Therms/yr loss

4. Energy savings 62 Therms/yr saved

5. Fuel Conversion 15 x 62 = 930 Gallons/kWh/yr saved

6. $ Savings Fuel cost per therm/gallon/kWh $ .04 x 930 = $37.20

7. Annual return on investment: $ Savings $37.20 / Cost of improvements $340 x 100 = 11 %

Table 5. Windows-Movable Sash

(therms of natural gas burned per season to replace heat lost through 10 sq. ft. of window)

		Degree-day zones								
		2000	3000	4000	5000	6000	7000	8000	9000	10000
Old Windows										
Single	Loose fit	14	21	29	37	45	53	60	68	76
Glazed	Loose fit, weatherstrip added	8	12	17	21	26	31	36	40	45
	Loose fit, weatherstrip, storm added	4	6	8	11	13	16	18	21	23
	Average fit	7	12	16	21	26	30	35	40	45
	Average fit, weatherstrip added	6	9	13	17	20	24	28	32	36
	Average fit, weatherstrip, storm added	3	5	7	9	11	13	15	17	20
New Windows										
Single	Aluminum	6	10	14	18	23	27	31	35	40
Glazed	Wood	6	9	13	17	20	24	28	32	36
	Storm added, aluminum	4	6	8	11	13	15	18	20	23
	Storm added, wood	3	5	7	9	11	13	15	17	20
Double	Aluminum	4	7	9	12	15	18	21	23	26
Glazed	Wood	4	6	8	11	13	16	18	21	23
	Storm added, aluminum	3	5	7	9	11	13	15	17	19
	Storm added, wood	2	4	6	7	9	11	12	14	16
	Low-E + argon, aluminum	3	6	8	10	13	15	17	20	22
	Low-E + argon, wood	3	5	7	9	11	13	15	17	20
	Storm added, low-E + argon, aluminum	3	4	6	8	9	11	13	15	17
	Storm added, low-E + argon, wood	2	4	5	6	8	9	11	12	14
Triple	Aluminum	3	6	8	10	13	15	18	20	23
Glazed	Wood	3	5	7	9	11	13	15	17	19
	Low-E + argon, aluminum	3	5	7	9	11	13	15	17	19
	Low-E + argon, wood	3	4	6	8	9	11	13	14	16

Windows-Fixed

(therms of natural gas burned per season to replace heat lost through 10 sq. ft. of window)

	U-Value	Degree-day zones								
		2000	3000	4000	5000	6000	7000	8000	9000	10000
Single glazed										
Aluminum	1.11	5	8	12	15	19	23	26	30	33
Wood	1.04	5	8	11	14	18	21	24	28	31
Single Glazed + Storm										
Aluminum	0.56	3	4	6	8	10	11	13	15	17
Wood	0.51	2	4	6	7	9	10	12	14	15
Double Glazed										
Aluminum	0.56	3	4	6	8	10	11	13	15	17
Wood	0.51	2	4	6	7	9	10	12	14	15
Double Glazed, Low-E + argon										
Aluminum	0.4	2	3	4	6	7	8	9	11	12
Wood	0.35	2	3	4	5	6	7	8	9	11
Double Glazed + Storm										
Aluminum	0.41	2	3	4	6	7	8	10	11	12
Wood	0.35	2	3	4	5	6	7	8	9	11
Triple Glazed										
Aluminum	0.41	2	3	4	6	7	8	10	11	12
Wood	0.35	2	3	4	5	6	7	8	9	11
Triple Glazed, Low-E + argon										
Aluminum	0.35	2	3	4	5	6	7	8	9	11
Wood	0.29	1	2	3	4	5	6	7	8	9

EXAMPLE 5 - WINDOWS

A house in a 6000 degree-day zone has 20 original poor-fitting double hung windows. The original storm windows and screens have deteriorated beyond salvaging. The owners are considering two options: (1) They can install aluminum storm windows and weatherstrip the existing sash. If the owners do this work themselves, the cost of storm windows and weatherstripping will be \$160/window, for a total of \$3200. (2) They are also considering having new replacement windows installed, and are interested in double glazed windows with low-E and argon gas. This option, with labor, will cost \$500/window, for a total of \$10,000. The house is heated with natural gas costing \$.50/therm. What kind of energy and cost savings can be expected for each option?

This question requires going through two worksheets, and comparing the savings of each option to the existing conditions. The first worksheet calculation is as follows.

1. **Area**. The area is 200 sq. ft. and the standard area in the table is 10 sq. ft., so the area adjustment is 20. This adjustment carries down to lines 2 and 3.

2. **Existing Energy Loss**. The existing energy loss from the table (Degree-day column "6000", R-Value row "loose fit") is 45 therms/year times 20, or 900 therms/year.

3. **Expected Energy Loss.** After the improvement, the expected energy loss (Degree-day column "6000", R-value row "loose fit, weatherstripped, storm added") is 13 therms/year times 20, or 260 therms/year.

4. **Energy Savings**. The improvement would save 900 - 260 = 640/year.

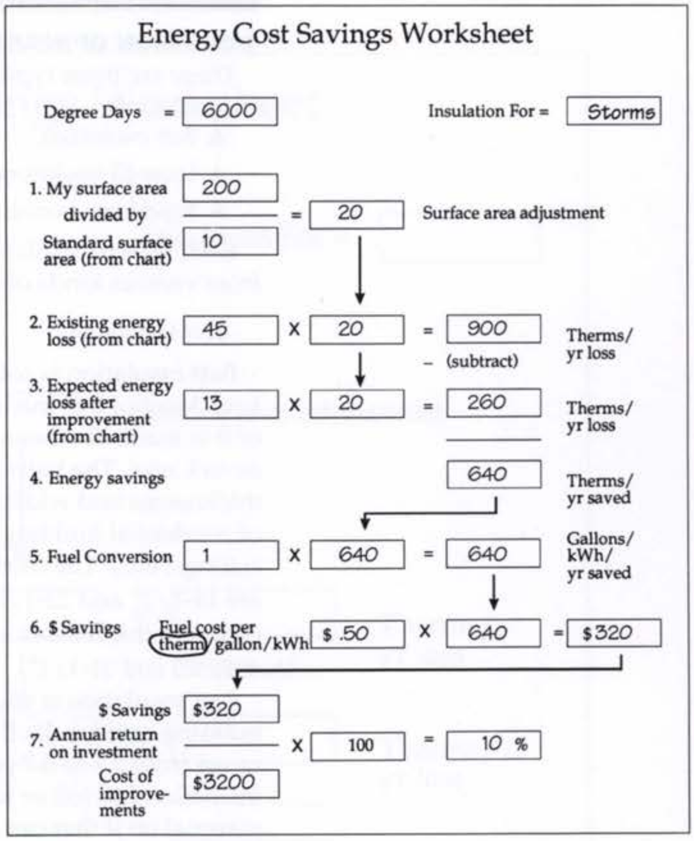
5. **Fuel Conversion**. Since the house is heated with natural gas, no fuel conversion is necessary.

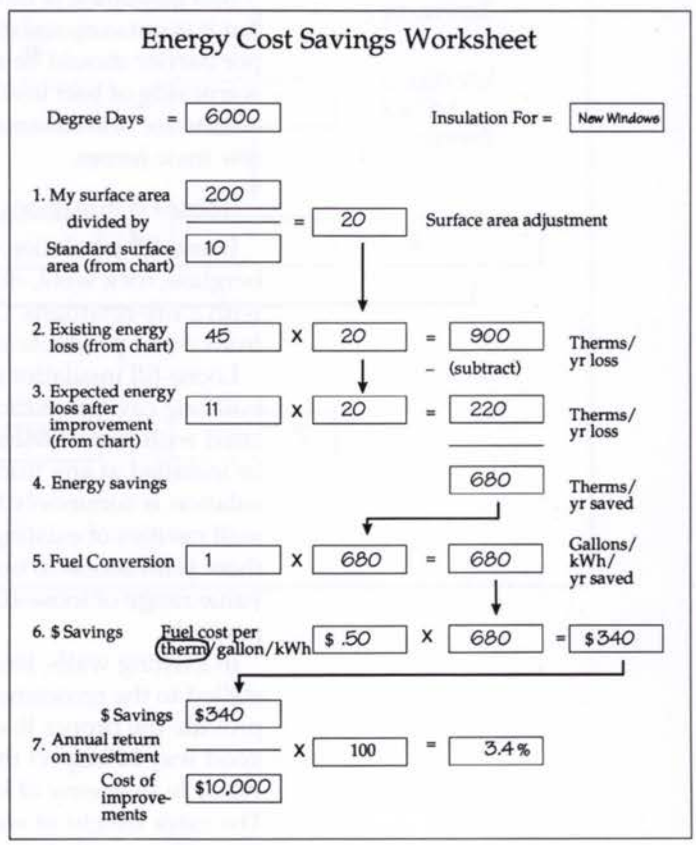
6. **\$ Savings**. At \$.50/therm, the improvement would save \$.50 x 640 = \$320/year.

7. **Return on Investment**. Dividing the savings by the cost of the improvement, one would expect a 10% annual return on investment.

The second worksheet follows the same procedure, and is shown.

Both options save considerable heating costs each year. The new replacement windows should save \$20 more a year in heating costs as compared to the first option (\$340 as compared to \$320). The return on investment, however, is far greater for saving the original windows and doing the work themselves (10% as compared to 3.4%). If the owners are committed to keeping up with the expected maintenance the old windows will certainly require (repainting, recaulking, etc.), they will see a much quicker return on their investment.





DISCUSSION OF INSULATING MATERIALS

There are three types of home insulating materials.

- Batt insulations,
- Loose-fill insulations, and
- Rigid foam boards.

Each type of insulation may be made from various kinds of material.

Batt Insulations

Batt insulation is sold in rolls or blankets. Most of it is made of *fiberglass*. Some of it is made of other mineral wools such as *rock wool*. The batts are of different thicknesses and widths matching widths of residential building cavities (walls, ceilings, etc.). The more common widths are 14-1/2" and 22-1/2" and the more common thicknesses are 3-1/2", 5-1/2", 9-1/2", and 11-1/2".

Batt insulation is used most often in building cavities. Its R-values usually range from 3.1 to 3.7 per inch. Most batt insulation has foil or Kraft paper facing material on it that can be stapled to the wall framing.

Batt insulation is moisture resistant, but it is not very resistant to vapor. A vapor barrier should be applied on the warm side of batt insulations. These insulations are non-flammable and give off few toxic fumes.

Loose-Fill Insulations

Loose-fill insulation can be made of fiberglass, rock wool, or cellulose treated with a fire-retardant. Cellulose is made from wood products such as newspaper.

Loose-fill insulations are blown into building cavities. Attics are often insulated with loose-fill insulation, which can be installed at any thickness. Loose-fill insulation is commonly blown into the wall cavities of existing homes because there is no access to install batts. The R-value range of loose-fill is from 2.2 to 3.7 per inch.

In existing walls, loose-fill should be installed to the recommended density to provide the proper R-value. There is no good way to inspect this type of work. Water is an enemy of loose-fill insulation. The extra weight of water promotes settling. Water will also reduce the R-value of cellulose insulation and possibly promote deterioration in the wood framing. Loose-fill insulations are very resistant to fire. This is true of cellulose loose-fill only *if* it has been treated with fire retardant.

Rigid Foam Boards

Rigid foam boards are made of different types of plastics and come in a variety of thicknesses. They are usually sold in 4' x 8' panels. The air trapped within and between the plastic cells slows the flow of heat. The R-values of foam board are usually clearly stated on the panel. They range from 3.8 to 8 per inch. This insulation is sold in large sheets that must be cut with a knife or saw. For this reason, it is not practical for insulating building cavities.

Rigid foam is often used in new construction as insulating sheathing to cover the outside of walls. Its slim profile and consistent thickness make it a good choice for insulating finished basement walls. Rigid foam demands less floor space than a full 3-1/2" wall for batt insulation. Foam boards that do not take in water easily are good choices for insulating the outsides of a foundation.

Fire is a concern with these insulations. Some plastics are highly flammable and produce toxic smoke when burned. For this reason, building codes require that a fire barrier be placed over the insulation.

Energy Cost Savings Worksheet

Degree Days = ______   Insulation For = ______

1. My surface area ______ divided by Standard surface area (from chart) ______ = ______ Surface area adjustment

2. Existing energy loss (from chart) ______ X ______ = ______ Therms/ yr loss

– (subtract)

3. Expected energy loss after improvement (from chart) ______ X ______ = ______ Therms/ yr loss

4. Energy savings ______ Therms/ yr saved

5. Fuel Conversion ______ X ______ = ______ Gallons/ kWh/ yr saved

6. $ Savings Fuel cost per therm/gallon/kWh $ ______ X ______ = $ ______

7. Annual return on investment

$$\frac{\text{\$ Savings } \$ \_\_\_\_\_\_}{\text{Cost of improvements } \$ \_\_\_\_\_\_} \times 100 = \_\_\_\_\_\_ \%$$

Heating Plant Efficiency

The tables in this publication are based on a furnace efficiency of 70 percent for both gas and fuel oil. Recent design improvements have resulted in furnaces that have an efficiency of 80 to 90 percent and higher. Our energy-saving calculations will be high if you are using a newer, more efficient furnace. The reduction in energy savings will be about the same percentage as the furnace efficiency is greater than 70 percent. For example, a furnace that runs at 80 percent efficiency will reduce the calculated savings by about 10 percent, and a furnace running at 90 percent efficiency will reduce the calculated savings by about 20 percent.

Basis for Calculations

The following assumptions were made in the calculation procedure used in this circular:

- a degree-day base of 65°F;
- an indoor air temperature of 70°F;
- R-values and U-values for materials as published in American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) tables;
- furnace and boiler efficiency of 70 percent for natural gas;
- calorific value of 140,000 Btu per gallon and efficiency of 70 percent for fuel oil;
- thermal value of 3412 Btu per kWh and efficiency of 100 percent for electrical resistance heating;
- performance as indicated for electrical heat pump heating;
- infiltration based on crackage method included in the heat loss for doors and windows;
- R-value for ceiling-roof combination based on an R of 3 (R-value of ceiling alone) and temperature difference taken from indoor to outdoor air; and
- modification in the "24" of the basic equation as in "Estimating Energy Requirements for Residential Heating," by Warren S. Harris and Calvin H. Fitch, *ASHRAE Journal*, October 1965.

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